MECHANICAL PROPERTIES OF HFCVD MICROCRYSTALINE DIAMOND COATED ON SEEDED WC SUBSTRATE

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To

My Beloved Family

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ABSTRACT

The mechanical properties and adhesion strength of a diamond film coated on cemented carbide has great significance in its performance as a cutting tool. Many studies have been conducted to improve the mechanical properties through the careful optimization of a variety of substrate pretreatment techniques. In this study, a two step chemically pretreated WC-6% Co was seeded with a solution of diamond powders (0.5µm) having fixed concentration (0.8 g/l) mixed with varying SiC powders (175µm) concentration of 1.0, 5.0 and 10.0 g/l respectively so as to produce different microcrystalline diamond film surface roughness. Diamond films were grown on the pretreated tungsten carbide (WC) substrates using hot filament chemical vapour deposition (HFCVD) technique for 30 hours with fixed parameter. Field emission scanning electron microscope (FESEM) images and x-ray diffraction (XRD) spectrums results indicates that all the diamond films have well faceted grains of (111) and (220) morphologies. The WC substrates etched and seeded with 1g/l of SiC mixed with 0.8g/l of diamond powders was found to have diamond coating with sharp peaks with uniform height and gaps between diamond grains when observed using atomic force microscope (AFM). Sand blasting technique was employed to determine the adhesion strength of the coated diamond film, where the sample seeded with a mixture of diamond with 5 g/l SiC powder concentration was found to have the highest diamond film adhesion strength. Nano-scratch tests show that all the diamond films have excellent adhesion with the mode of deformation found to be cohesive chipping rather than adhesive failure. Nano-indentation tests using Berkovich indenter revealed that the substrate seeded with diamond mixed with 5 g/l concentration of SiC powders was found highest in hardness (104.3 GPa) and modulus(1115 GPa) which is comparable to natural diamond properties.

ABSTRAK

Sifat mekanik dan daya rekatan salutan lapisan intan ke atas permukaan karbida tersimen mempunyai kesan yang besar kepada prestasinya sebagai alat pemotong. Banyak kajian telah di jalankan untuk meningkatkan sifat mekanik ini melalui proses pengoptimuman berhati-hati pelbagai teknik pra-rawatan substrat karbida. Dalam kajian ini, tungsten karbida (WC-6wt% Co) substrat yang telah di pra-rawat kimia dua langkah telah dibenihkan dengan campuran serbuk intan (0.5µm) dengan konsentrasi yang telah ditetapkan (0.8 g/l) dan serbuk SiC (175µm) berkonsentrasi masing-masing 1.0, 5.0 dan 10.0 g/l dengan tujuan untuk menghasilkan kekasaran permukaan salutan intan habluran yang berbeza. Salutan lapisan intan ke atas substrat WC telah di hasilkan melalui kaedah pengendapan wap kimia filamen panas (HFCVD) selama 30 jam dengan parameter salutan yang telah ditetapkan. Imej mikroskop imbasan electron pancaran lapangan (FESEM) dan spektra pembelauan sinar-x (XRD) menunjukkan bahawa semua saluatan intan mempunyai bijian yang bersegi dengan campuran morfologi (111) dan (220). Substrat WC yang di pra-rawat dan di benihkan dengan campuran serbuk 1g/l SiC dan 0.8 g/l serbuk berlian didapati mempunyai salutan intan dengan puncak yang tajam serta ketinggian dan jarak anatara bijian yang seragam apabila di analisa menggunakan mikroskop tenaga atomic (AFM). Teknik letupan pasir telah di guna untuk menentukan kekuatan daya rekatan lapisan salutan intan dimana sampel yang dibenihkan dengan campuran serbuk 5 g/l SiC dan serbuk intan didapati mempunyai daya rekatan yang tertinggi. Ujian calar-nano menunjukkan bahawa semua lapisan intan mempunyai daya rekatan yang baik dengan hanya menunjukkan mod ubahbentuk serpihan tanpa sebarang kegagalan rekatan. Sementara ujian pelekukan-nano menggunakan pelekuk Berkovich mendedahkan bahawa substrat yang dibenihkan dengan campuran serbuk intan dan yang serbuk 5 g/l SiC mempunyai nilai kekerasan (104.3 GPa) dan modulus (1115 GPa) tertinggi yang setanding dengan sifat intan yang asli.